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INVESTMENTS IN RESEARCH ACTIVITIES OF THE MANUFACTURING INDUSTRY AND INNOVATIVENESS IN ECONOMY OF THE REPUBLIC OF SERBIA

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Review paper

Abstract: The aim of the study in this paper is to examine the effects o investment in research and development activities of the manufacturing industry on the innovativeness in economy of the Republic of Serbia, and to draw conclusions in which direction further investments should be managed, bearing in mind that the importance of the processing industry for the overall economy has been growing from year to year. The comparative analysis shows the movement of the basic indicators o the manufacturing industry sector, as well as the movement of three basic indicators of the innovativeness in economy of the Republic o Serbia: GII (Global Innovation Index), GCI (Global Competitiveness Index) and SII (Summary Innovation Index). Based on the application o regression and correlation analysis, a weak contribution of gross domestic expenditures for research and development in the manufacturing industry to the improvement of the innovativeness in economy of the Republic of Serbia can be seen. On the other hand, a strong connection was established between the total gross domestic expenditures for research and development (at the level of the economy and indicators of economic innovation, which indicates the need to restructure research and development expenditures in the direction o the manufacturing industry, with the aim of its greater contribution to the innovation of the overall economy. The progress of the economy of the Republic of Serbia viewed through the ranking and points of the used indicators of innovation can be attributed to investments in research and development activities in the area of other sectors of the economy, which can be the subject of some future research.

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1. Introduction

There is a pronounced correlation between the development of economy and the development of science, technique and technology, that is, they are the cause and effect of each other. That is why the degree of economic development is higher in countries where science, technique and technology are developed, and vice versa. Investments in research and development activities represent a key determinant of innovation activities in all developed countries. They represent private sources of research activities within companies, and also sources of public investment in research and development. Since the costs of research and development activities are often part of public expenditures, their adequate direction should lead to an efficient allocation and optimal use of available funds for that purpose (Prokop et al., 2019).

One of the economic sectors where innovations are widespread is the sector of the manufacturing industry and it experiences fundamental changes in the modern age of digitization. Namely, industry is "the first medium on which the results of the development of science, technique and technology are applied, and it develops due to the development of technique and technology (technical-technological progress), that is, it conditions that progress." The industry has a great impact on constant shortening of the time concerning revolutionizing certain solutions in technique and technology. Revolutionizing in the field of means of work takes place in less than ten years (5-7 years), and revolutionizing in the field of technology even in less than five years" (Gligorijević & Bošković, 2021, p. 238). The nature of production is changing to the extent that the physical processes of production represent only one element of a much wider value chain, generating new and additional revenues, before and after the production activities. The traditional division into design, procurement, production and delivery of goods and services is collapsing, while future trends require manufacturing companies to improve collaboration and investment across the entire value creation system. Therefore, innovations and companies that are the first to adopt them are of great importance, whether they are large corporations, original equipment manufacturers or highly specialized small and medium-sized enterprises that produce "smart" products. Enterprises, early adopters of innovation, are industry leaders and have already been gathering the benefits of digital transformation (Devitt, 2017, pp. 2-7).

The subject of this paper is an examination of the impact and significance of research and development activities in the area of the manufacturing industry on the economy innovativeness, on the example of the Republic of Serbia. The paper conisits of four parts. In the first and second part of the paper, the theoretical views on the impact of research and development activities on the innovativeness of the economy and economic growth were presented, and then the basic indicators of the economy innovativeness of the Republic of Serbia. In the third part, the results of the movement of basic indicators of the manufacturing industry of the Republic of

Serbia are presented, while in the fourth, the relationships between the investment in research and development activities of the processing industry and the indicators of the economy innovativeness of the Republic of Serbia are analyzed, by using correlation and regression analysis.

2. The impact of research and development activities on the innovativeness in economy and economic growth - review of the literature

Innovations occupy a central place in the development of the economy and changes in its structure, which is also reflected in economic growth. They are extremely diverse and according to the undivided opinion of economic researchers, they dominantly shape almost all areas of economy, including the industry sector. The relations between the innovation and the development of industry, and thus the development of economy, are extremely complex and often contradictory in nature. In this sense, research and development activity, that is, scientific research work, in modern conditions, is one of the key factors in the development of industry. Although, it is the need of every country, the approach to its development is different. Countries that have a developed industry develop scientific research work, in order to maintain the position they have gained on the international level; underdeveloped countries, on the other hand, develop scientific research work with the aim of improving their position on the international level. The development of scientific research has a special importance in the field of technique and technology, because they revolutionize the development of economy as a whole, especially industry. The following conditions are necessary for the success in its development: (a) funds for financing scientific research work, (b) staff capable of engaging in scientific research work and (c) application of achieved scientific and technical solutions. At the same time, the moment when these solutions are applied is particularly important, and also the time in which these technical and technological solutions can be applied. (a) Funds for financing scientific research depend on the amount of national income and the possibility to set aside a certain part for that financing. At the same time, the opportunities are much greater in countries with more developed economy than in countries with less developed economy. However, this does not mean that the level of allocation of national income for the financing of scientific research work, per inhabitant, must be different. Evident absolute differences do not mean that relative differences must also be present. Namely, it is possible to allocate the same funds per resident. However, the funds allocated in this way, due to the low absolute amount, do not allow developing countries to achieve a faster pace of development of science, technique and technology. Therefore, such countries are forced to use scientific, technical and technological solutions from developed countries. (b) The number and quality of personnel engaged in scientific research depends on the degree of economic development. In the initial stage of industrialization, countries are mainly

oriented towards the employment of a large number of the working-age population. However, as the workforce reaches a certain level of development, it undergoes a transformation. There are increasing demands for workforce that has certain qualifications and for personnel who will be engaged in scientific research work (the research and the application of the results). (c) The third condition that affects technical-technological progress is the application of achieved scientific and technical inventions. Technical and technological progress does not lead to progress if its results are not applied when they are determined. In addition, if their application is delayed, they cannot produce the effects that could be achieved if their application occurred at the moment of their determination. This is due to the fact that science, technique and technology do not stand still, but constantly advance, and the most modern technical and technological solutions become obsolete very quickly (Gligorijević & Bošković, 2021, p. 245-246).

Looking at the macro level, or the level of countries, there are several studies that examined the impact of research and development activities on the innovativeness in economy in different countries. Together with collaborators, González X. investigated the need for public subsidies of research and development activities and their importance in companies in the territory of Spain (González et al., 2005. pp. 930-950). Czarnitzki and others have analyzed the effectiveness of innovation policies supporting joint research and development activities in German and Finnish companies. It was concluded that in German companies, innovation performance could be improved by public incentives from the budget for joint research and development activities between companies. The result of the research of Finnish companies showed that public spending aimed at financing research and development activities in companies is crucial for their business (Czarnitzki et al., 2007. pp.1347-1366).

In their research, Prokop V., Stejskal J. and Hajek P. proved the influence of different ways of financing research and development activities and their contribution to increasing the innovation potential and, consequently, the performance of the entire economy. They came to the conclusion that all developed economies apply some form of public policies aimed at supporting research and development activities (Viktor et al., 2019, pp. 5-13). According to Kim et al., research and development activities and the government's innovation support system are considered necessary factors for improving technological and service innovation performance in South Korea. According to the conclusion of the mentioned authors, the Korean innovation support system showed that programs to support them can be classified as support for tax incentives, finance, technological development, human resources, consumption, law and institutional infrastructure or other indirect support for innovation (Kim et al. 2016).

A strong link between research and development activities and innovation at the macro level ensures sustainable economic growth. This connection was studied by Ulka H., using various econometric methods and data on research and

development activities and registered patents in 20 OECD member states and 10 non-OECD member states, for the period from 1981 to 1997. The result of his work indicates a positive relationship between GDP per capita and the number of innovations both in countries within and outside the OECD, while the impact of research and development activities is significant only in OECD member states with large markets (Ulku, 2004, pp. 4- 34).

One of the most important facts, when it comes to national economies, concerns the exceptional capacity of innovations in stimulating economic growth, since they can play a key role in maintaining the competitiveness of the national economy on the medium and long term basis. It can also play a key role in improving the national innovation capacity, which is essential for ensuring the long-term economic growth. Such national innovation capacity can be improved by encouraging research and development activities, funding sufficient academic research and strengthening the link between industry and universities, in order to improve the connection between research and development activities and economic development. The main policy tools to support research and development activities by the government include grants, tax incentives and direct research implementation (Savrul & Incekara, 2015, pp. 388 – 396).

Long-term national investments in basic and applied research and development play an important role in the flow of market-based innovations through a complex system that leverages the combined talents of scientists and engineers, entrepreneurs, business managers and industrialists. "These funds have led to everything from small entrepreneurial initiatives to growth in high technology industries with the concomitant employment of millions of workers. The large impact on employment results from innovation impacts not only in high tech enterprises, but also other industries that benefit from increased capabilities and productivity. Mutually reinforcing and complementary investments in R&D by both private and public sectors work in concert to support the development, production, and commercialization of new products and processes" (National Science Board. 2012).

3. Indicators of innovativeness in economy of the Republic of Serbia

All innovations must contain novelty to a certain degree, whether that novelty is something new for the company, economic activity or branch, market or for the economy as a whole. Innovations represent the use and application of available knowledge with the aim of its commercialization. Schumpeter distinguished between product innovations, process innovations, organizational innovations and innovations that include the development of new raw materials' sources. The OECD (2005, 33-36) distinguishes four types of innovation in the "Oslo Guidelines": (a) product innovation, (b) process innovation, (c) marketing innovation and (d) organizational innovation. The first two types are closely related

to the traditional understanding of innovation, which is based on technological innovation, while the next two are non-technological in nature and represent a novelty in the modern understanding of innovation. Recently, researchers have pointed to the fact that besides the so-called standard, there are more innovations of an aesthetic or intellectual nature, which are often completely ignored in economic analyses. Examples of such innovations are especially related to the so-called creative industries. But, regardless of how they are described, innovations are important due to the fact that they have a stimulating effect on increasing productivity, employment and profits in companies. They improve the quality of life and competitiveness at all levels. The ability to innovate is inevitably linked to the competitiveness of individual companies, economic branches and the economy as a whole, and in this sense, innovative activity represents an important source of economic growth in any economy. The purpose of innovation is to improve economic and social development, whereby the quality of innovation is more important than the quantity of innovative solutions.

Three indicators were used in the paper as the indicators of innovation in economic performance of the Republic of Serbia: GCI (Global Competitiveness Index), GII (Global Innovation Index) and SII (Summary Innovation Index).

Moreover, the assessment of innovation performance was carried out on the basis of the values of two composite indices - *the Summary Index of Innovation*, which is presented in the framework of the European Innovation Scoreboard report of the European Commission and which measures performance relative to the average of the EU member states and the *Global Index of Innovation*. Cornell University, the European institute INSEAD and the World Intellectual Property Organization in cooperation with other organizations and institutions annually rank about 130 countries of the world according to the success of innovations and achieved innovative performance based on the Global Index of Innovation.

First, in Table 1, the Summary Index of Innovation (SII) of the economy of the Republic of Serbia is shown in points, which is used to measure the innovatiion performance of predominantly European countries (Janoskova & Kral, 2019, pp. 68–83). This index consists of four groups of indicators and 10 dimensions (27 indicators in total). Four basic groups of indicators include: System conditions, Investments, Innovative activities and Impacts. (a) *System conditions* refer to the basic drivers of innovation performance that are monitored through three dimensions - human resources, an attractive research system and an environment that encourages the innovation. (b) *Investments* include investing in the public and private sectors and are monitored through two dimensions - finance and support for innovative and research activities and investments by business entities. (c) *Innovative activities* include different aspects of innovation in the private sector and are tracked through the dimensions of innovators, connections and intellectual property. (d) Within the *Impacts* indicator, the effects of innovative activities of business entities on employment and sales are monitored. Statistical data from the

Eurostat database and other internationally relevant sources such as the OECD and the United Nations are used to calculate the Summary Index of Innovation. Data for all 27 indicators are available for 26 member countries. Based on the values of the Summary Index of Innovation of all analyzed countries, and in relation to the average values at the EU level, the countries are divided into four categories: innovative leaders (achieving performance that is at least 20% above the EU average), innovative followers (achieving performance up to 10% below and up to 20% above the EU average), moderate innovators (perform 10% to 50% below the EU average) and modest innovators (perform at least 50% below the EU average) (Beraha, 2019, pp. 139-140).

Table 1 Presentation of SII economy of the Republic of Serbia according to points

Year	SII (Summary Innovation Index)-points (indices)
2014	58
2015	57
2016	58
2017	57
2018	58
2019	59
2020	61
2021	66

Source: Author's work based on data collected from: *https://ec.europa.eu/info/index_en*

Based on the data from Table 1, it can be noticed that the SII moves around 58 points, in the period from 2014 to 2018, with a tendency to grow to the final 66 points in 2021. The Republic of Serbia is ranked among moderate innovators that achieve performance from 10% to 50% below the EU average (Beraha, 2019, p. 144).

The second composite index is the *Global Innovation Index* (GII), on the basis of which Cornell University, the INSEAD institute and the World Intellectual Property Organization, in cooperation with other organizations and institutions, annually monitor and rank the innovation performance and success of innovations in about 130 countries of the world. The GII includes 84 indicators and is calculated based on the average of the results of two sub-indices - Innovative capabilities and Innovative result. The *Innovative Capability* sub-index measures the innovation potential of the economy and consists of five pillars – institutions, human capital and research, infrastructure, market sophistication and business sophistication (Dutta et al., 2018).

Table 2 Rank GII economy of the Republic of Serbia

Year	GII(Global Innovation Index)- rank
2014	67
2015	63
2016	65
2017	62
2018	55
2019	57
2020	53
2021	54

Source: Author's work based on data collected from: *https://www.globalinnovationindex.org*

(a) *Institutions* include the political, regulatory and business environment, which provides an institutional framework for developing innovation and fostering growth through adequate governance; (b) *Human capital and research* - the level and standard of education, as well as research abilities, represent one of the most important drivers of innovation; (c) *Infrastructure* includes information and communication technologies and environmental sustainability as important parameters in creating an environment for generating innovations; (d) *Market sophistication* includes credit availability, investment, trade, competition and markets; (e) *Business sophistication* refers to the acquisition of new knowledge. *The Innovative Score* sub-index measures the innovativeness of the produced output and consists of two pillars – *knowledge and technological capability* (creation, impact and diffusion of knowledge) and *creative capability* (intangible assets, online creativity and creative goods and services). All the listed pillars describe the innovation attribute and consist of 9 to 15 indicators, and the score is calculated based on weighted averages.The economy of Serbia has recorded an improvement in its position according to the Global Innovation Index since 2014, and from the 67th position in 2014, it advanced to the 54th position in 2021 (Table 2). However, despite the progress, Serbia continued to lag behind most of the neighboring countries, and was ranked better only than Bosnia and Herzegovina, Albania and Macedonia. The most favorable position on the ranking list is achieved by Serbia in the area of Infrastructure, where it is the least behind Switzerland, as the best-ranked country, while the worst position is in the market sophistication segment, which refers to access to credit, investor protection, customs rates and local competition (Beraha, 2019, p. 146).

Globalization and the fourth industrial revolution have created both new opportunities and disruptions and polarization within and between different

economies and societies. For this reason, in 2018, the World Economic Forum renamed the Global Competitiveness Index (GCI) to GCI 4.0.

Table 3 Rank of GCI economy of the Republic of Serbia

Year	GCI (Global Competitiveness Index) - rank
2014	94
2015	94
2016	90
2017	78
2018	65
2019	72
2020	No data (due to COVID-19)
2021	No data (due to COVID-19)

Source: Author's work based on data collected from https://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2019.pdf

The focus of GCI 4.0 is on institutions, policies and factors that encourage productivity in the economy of individual countries (Schwab, 2017, pp 37-38). The index is an annual benchmark for economic policy makers who need to assess the progress of the economy based on a complete set of factors that determine global productivity. The set of GCI determinants is organized into 12 columns: institutions, infrastructure, ICT adoption, macroeconomic stability, health system, skills, product market, labor market, financial system, market size, business dynamism and innovation capability.

Based on the data from Table 3, it can be noticed that the economy of the Republic of Serbia, between 2014 and 2018, recorded a constant growth in position, and in 2019, there occurred a slight drop to the 72nd position. Since 2020, due to the spread of the COVID-19 pandemic, GCI has not been counted.

4. Movement of basic indicators of the manufacturing industry of the Republic of Serbia

Over 85% of global industry exports consist of technology-intensive products, and even less than 15% of labor-intensive products, which explains the impact of innovation on changing the structure of industrial production on a global scale. The export of technology-intensive products is dominated by products whose production requires highly specialized work skills, such as chemical and pharmaceutical products, plastic products, communication and office machines and equipment, aircraft and related equipment, electrical machines and apparatus and

other complex products. The share of these products in total industry exports increased in 2014 to 41.6% compared to 1995, when it was 37.7% (UNCTADstat).

Table 4. Overview of the participation of the manufacturing industry in GDP, the trends in VAT and the growth rate of production in the manufacturing industry of the Republic of Serbia in the period 2014-2021.

Year	Share of manufacturing industry in GDP	GDP of the manufacturing industry of the Republic of Serbia (in euros)	Production growth rate in the manufacturing industry
2014	15,7%	44.579.699	-0,4%
2015	15,6%	43.334.432	+5,3%
2016	15,6%	43.965.683	+6,0%
2017	15,1%	48.727.529	+6,3%
2018	14,5%	52.686.017	+1,9%
2019	13,9%	53.304.148	+0,2%
2020	13,3%	52.841.502	+0,1%
2021	13%	58.979.339	+5,6%

Source: Author's work based on data collected from the website of the Republic Institute of Statistics: https://www.stat.gov.rs/

The total export of the processing industry in the first decade of the 21st century was 93% of the total export of Serbia. Therefore, the sector of the processing industry dominated, both absolutely and relatively, in the total export of the Serbian economy. However, exports are characterized by an unfavorable structure and low competitiveness, as the largest share was in the areas of basic metals (18.8%), food products and beverages (15.6%), chemicals and chemical products (9.3%), rubber products and plastics (6.9%), and machines and devices (6.6%) (Savić & Mićić, 2021, p. 150). In the period from 2010 to 2018, production was recovering and export intensity was increasing. The cumulative export value of the manufacturing industry in the second decade of the 21st century was about 89.4% of the total export, which is a confirmation that it is a dominant sector when it comes to tradable goods. Relatively the largest export was achieved in the machinery and transport equipment sector (23.6%), followed by semi-products of various branches of the processing industry (metals and car tires), as well as consumer products (clothing and furniture) (Savić & Mićić, 2021, p. 152). The difficult-to-foresee challenges of technological changes on a global level, which the fourth industrial revolution brings with it, require a dynamic direction and a more radical structural transformation of the industry of the Republic of Serbia. It is necessary to define an appropriate and sophisticated industrial policy in order to meet the needs of digitization, reindustrialization, new jobs, achieving sustainable

economic development and raising the quality of life. In this sense, a special emphasis should be placed on directing the development of the manufacturing industry. Thus, we should look at its importance for the economy of the Republic of Serbia, based on a comparative analysis of the trends in the share of the manufacturing industry in the GDP, GVA of the manufacturing industry, the growth rate of production (Table 4) and trends in employment in the manufacturing industry (Table 5).

Although, based on the data from Table 4, there is a slight tendency to decrease the relative share of the manufacturing industry by about 2.7% (from 15.7% to 13.0%) in the period from 2014 to 2021, the GVA of the manufacturing industry was in constant growth in the same period, and expressed in euros, it recorded an increase from 44,579,699 euros in 2014 to 58,979,339 euros in 2021. From the same table, it can be seen that the production of the processing industry is constantly increasing, with the exception of 2014. During 2019 and 2020, a significant decrease in the growth rate is recorded, as a consequence of the development of the COVID-19 pandemic, while in 2021, the pandemic will subside slightly at the national level and the growth rate of the manufacturing industry will increase again to 5.6%.

Table 5. Trends in employment in the manufacturing industry of the Republic of Serbia

Year	Employment in the manufacturing industry	Growth rate of employment in the manufacturing industry
2014	279.289	-2,8%
2015	380.325	+36,17%
2016	393.906	+3,57%
2017	417.564	+6,0%
2018	444.888	+7,3%
2019	459.467	+3,27%
2020	467.040	+1,65%
2021	493.413	+5,6%

Source: Author's work based on data collected from the website of the Republic Institute of Statistics: https://www.stat.gov.rs/

Based on the data from Table 5, a constant growth of employment in the manufacturing industry can be observed. After a slight drop of -2.8% in 2014, there is a record increase in employment by +36.17% in the following year 2015. By 2021, the number of employees has grown to about 493,413, about 214,000 more, compared to 279,289 in 2014.

5. Analysis of the relationship between research and development activities of the manufacturing industry and innovativeness in economy of the Republic of Serbia

This part of the paper analyzes the relationship between the total gross domestic expenditures of the Republic of Serbia for research and development, the gross domestic expenditures of the manufacturing industry and indicators of innovation. Pearson's correlation coefficient and regression analysis were used as statistical methods. The need to restructure gross domestic expenditures for research and development in the manufacturing industry was pointed out, based on the impact of total gross domestic expenditures on indicators of innovation, examined in the period from 2014 to 2021.

Table 6. Relative ratio of gross domestic expenditures for research and development activities in the manufacturing industry and total gross domestic expenditures at the level of RS

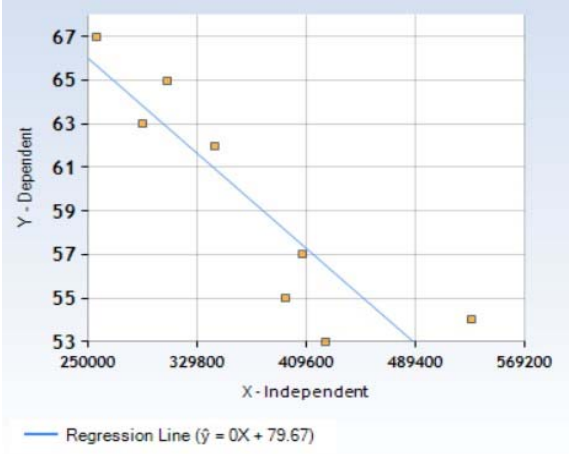
Year	Total expenditures for R&D (in 000 euros)	Expenditures for R&D in the manufacturing industry (in 000 euros)	Share of gross domestic expenditures for R&D in the manufacturing industry in relation to total gross domestic expenditures for R&D at the level of RS
2014	256.452	8.787	3,4%
2015	289.825	9.222	3,2%
2016	308.287	7.463	2,4%
2017	342.298	9.737	2,8%
2018	394.146	9.301	2,4%
2019	407.296	17.216	4,2%
2020	423.978	10.549	2,5%
2021	530.156	7.422	1,4%

Source: Author's work based on data collected from the website of the Republic Institute of Statistics: https://www.stat.gov.rs/

Based on the data from Table 6, a constant growth of the total gross domestic expenditures for research and development can be observed. From 256,452,000 euros in 2014, total expenditures have increased by about 107% in 2021, i.e. to 530,156,000 euros. There is also a slight downward trend in the relative share of gross domestic expenditures for processing, from 3.4% in 2014 to 1.4% in 2021, except for a jump to 4.2% in 2019, which means that there was no significant increase in gross of domestic expenditures for research and development in the manufacturing industry sector.

As it can be noticed from the data shown in Figure 1, there is a very high negative correlation between total gross domestic expenditure on research and development (grouped by industry) and the Global Innovation Index (GII). Its value is -0.8927 for the period from 2014 to 2021. It is obtained by applying the Pearson correlation coefficient. The coefficient of the direction of the regression line is Y= -0.00005X + 79.669, which means that with an average increase in gross domestic expenditures for research and development by 1 euro, there is an improvement in the position by 0.00005, that is, with an average increase in gross domestic expenditures for research and development by 20,000 000 euros, the economy of the Republic of Serbia advances by one position on the ranking list compared to other countries in the world. On the X-axis, as an independent variable, total gross domestic expenditures for research and development are presented, and on the Y-axis the position of the economy of the Republic of Serbia in the world, based on the GII.

Figure 1 Graphic representation of the regression line between total gross of domestic expenditures for research and development and GII of the economy of the Republic of Serbia

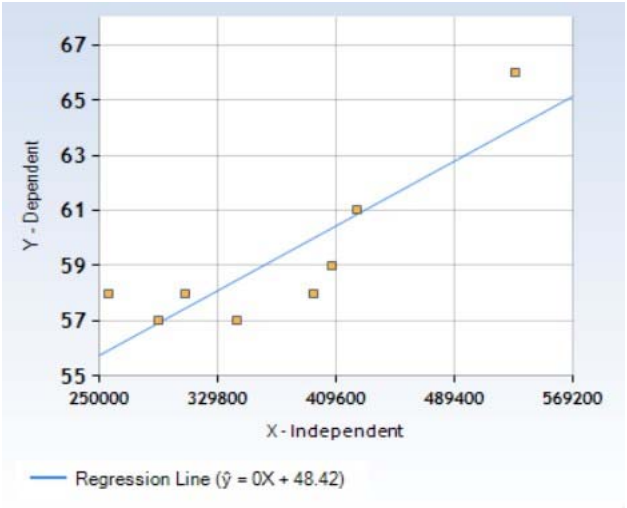


Source: Author's work based on data collected from: https://www.stat.gov.rs/

As it can be seen from the data shown in Figure 2, there is a very high positive correlation between total gross domestic expenditure on research and development (grouped by industry) and the Summary Innovation Index (SII). Its value is 0.8595 for the period from 2014 to 2021. It is obtained by applying the Pearson correlation coefficient. The summary innovation index, which may represent the most comprehensive indicator of innovative performance, as already mentioned, consists of 4 groups of indicators on the basis of which it is calculated: system conditions, investments, innovative activities and impacts. The coefficient of the direction of the regression line is Y= 0.00003X + 48.416, which means that with an average

increase in gross domestic expenditures for research and development by 1 euro, there is an improvement of 0.00003 points, that is, with an average increase in gross domestic expenditures for research and development by about 33.333 .333 euros, there is an improvement in the position of the Republic of Serbia by one point in the overall SII score, which affects the improvement of its position in relation to other countries in the world. On the X-axis, as an independent variable, total gross domestic expenditures for research and development are presented, and on the Y-axis the SII score of the economy of the Republic of Serbia.

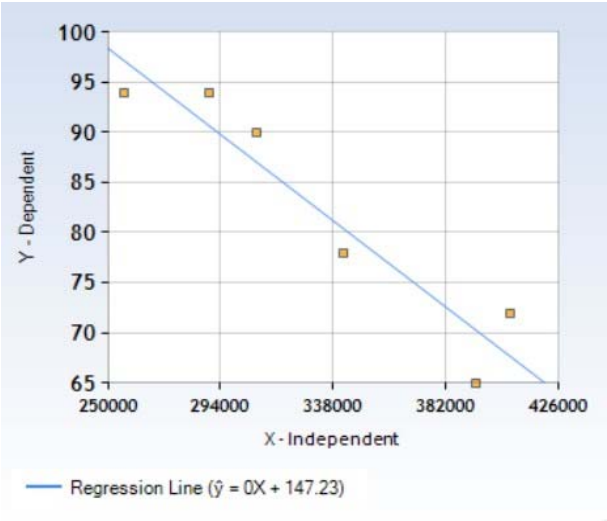
Figure 2 Graphic representation of the regression line between total gross domestic expenditures for research and development and SII of the economy of the Republic of Serbia



Source: Author's work based on data collected from: https://www.stat.gov.rs/

Based on the data shown in Figure 3, it can be seen that there is a very high negative correlation between gross domestic expenditure on research and development (grouped by activities) and the Global Competitiveness Index (GCI). Its value is -0.9443 for the period from 2014 to 2019. It is obtained by using the Pearson correlation coefficient. The coefficient of the direction of the regression line is Y= -0.0002X + 147.23, which means that with an average increase in total gross domestic expenditure on research and development by 1 euro, there is an improvement in the position by 0.0002, i.e. with an average increase in gross domestic expenditure on research and development by around 5,000,000 euros, the economy of the Republic of Serbia advances by one position in the ranking list compared to other countries in the world. On the X-axis as an independent variable, the total gross domestic expenditures for research and development are presented, and on the Y-axis the GCI of the economy of the Republic of Serbia.

Figure 3 Graphic representation of the regression line between the total gross domestic expenditures for research and development and the GCI of the economy of the Republic of Serbia

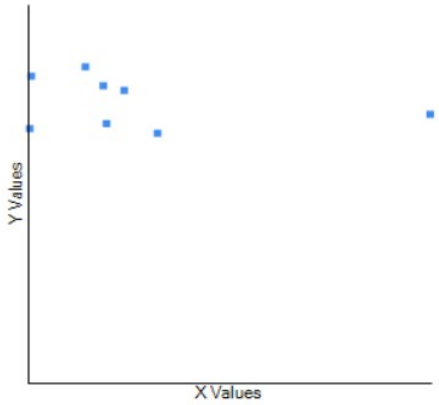


Source: Author's work based on data collected from: https://www.stat.gov.rs/

By using the Pearson correlation coefficient, based on the data from Table 6 and Figure 4, it is concluded that there is a weak negative correlation between gross domestic expenditures for research and development (grouped according to manufacturing industry activities) and GII. Its value is -0.2606 for the period from 2014 to 2021. This means that the changes in GII economy of the Republic of Serbia cannot be explained by changes in gross domestic expenditures grouped according to the activities of the manufacturing industry. On the X-axis as an independent variable, gross domestic expenditures for research and development in the manufacturing industry are presented, and on the Y-axis - the ranking of the GII economy of the Republic of Serbia.

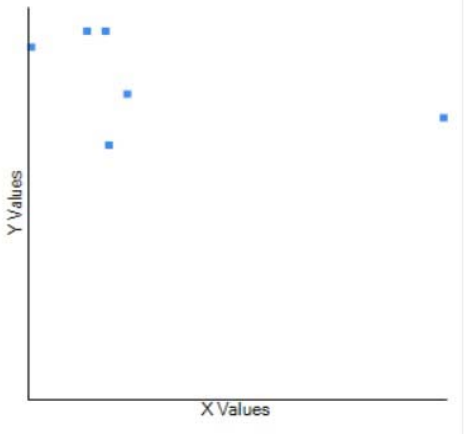
Additionally, using the Pearson correlation coefficient, based on the data from Table 6 and Figure 5, it can be observed that there is a moderate negative correlation between gross domestic expenditures for research and development (grouped according to the activities of the manufacturing industry) and GCI. Its value is -0.484 for the period from 2014 to 2019. This means that only to a certain extent, changes in the GCI of the economy of the Republic of Serbia can be explained by changes in gross domestic expenditures grouped according to the activities of the manufacturing industry. On the X-axis, gross domestic expenditures for research and development in the manufacturing industry are presented as an independent variable, and on the other hand, Y-axis the GCI rank of the economy of the Republic of Serbia.

Figure 4 Graphic representation of the correlation between gross domestic expenditures for research and development grouped according to the activities of the processing industry and GII economy of the Republic of Serbia



Source: Author's work based on data collected from: https://www.stat.gov.rs/

Figure 5 Graphic representation of the correlation between gross domestic expenditures for research and development grouped according to the activities of the processing industry and GCI of the economy of the Republic of Serbia

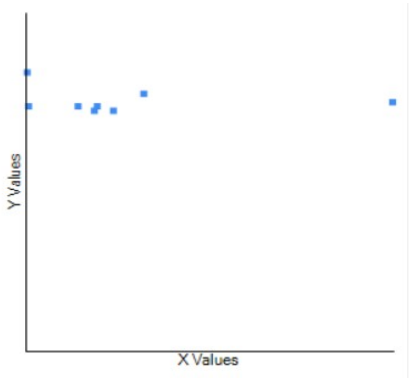


Source: Author's work based on data collected from: https://www.stat.gov.rs/

Finally, based on the same methodology, using the data from Table 6 and Figure 6, we observe that there is a very weak negative correlation between gross domestic expenditures for research and development (grouped according to the activities of the manufacturing industry) and SII. Its value is -0.1573 for the period from 2014 to 2021. This means that changes in the SII economy of the Republic of

Serbia cannot be explained by changes in gross domestic expenditures grouped according to the activities of the manufacturing industry. On the X-axis, as an independent variable, gross domestic expenditures for research and development in the manufacturing industry are presented, and on the Y-axis, SII of the economy of the Republic of Serbia is presented.

Figure 6 Graphic representation of the correlation between gross domestic of the processing industry and SII economy of the Republic of expenditures for research and development grouped according to the activities Serbia



Source: Author's work based on data collected from: https://www.stat.gov.rs/

Based on the calculated indicators, in all three cases, a very strong (positive or negative) correlation (-0.8927, 0.8595, -0.9443) can be observed between the total gross domestic expenditures for research and development and indicators of economy innovativeness of the Republic of Serbia. On the other hand, a very weak, weak and moderate negative correlation was calculated (-0.2606, -0.484, -0.1573) between gross domestic expenditures for research and development in the processing industry and indicators of economy innovativeness of the Republic of Serbia. The calculated indicators show that it is almost impossible, or only to a certain extent, to explain changes in the indicators of innovativeness in economy of the Republic of Serbia by changes in gross domestic expenditures for research and development in the manufacturing industry, although there is a strong to very strong correlation between total gross domestic expenditures and indicators of innovation. It can be concluded that a strong to very strong correlation is a consequence of gross domestic expenditures in another branch of the economy and that it is necessary to restructure gross domestic expenditures for research and development in the area of the manufacturing industry, in order to achieve a more significant impact on the growth of innovation in the economy of the Republic of Serbia.

6. Conclusion

In the literature in which the authors examined the impact of research and development activities on economic growth, innovations were pointed out as a significant determinant of the economic growth of certain countries, which are the result of investments in research activities, either through public or private investments of individual companies. Investments in scientific and technological infrastructure, research and development and the field of advanced technologies, coordination of the public and private sectors will create a positive atmosphere for innovation. Therefore, it is useful to analyze the effects of investments in research and development activities in certain branches of economy on the growth of innovations and the overall innovativeness in economy. The problem is the lack of standardized variables through which it is possible to see the effects of research and development activities on innovation; however, the authors decided to analyze SII, GII and GCI (GCI 4.0) as indicators of innovation in economy. The sector in which investments in research and development activities were analyzed is the manufacturing industry.

The importance of the processing industry in the overall structure of the economy of the Republic of Serbia is growing year by year. This is supported by the indicators of the increase in the number of employees, gross added value, and the growth rate of production in the manufacturing industry. A special challenge for the manufacturing industry is the digital transformation of business processes that is happening around the world. Therefore, it is necessary to focus on innovations that will enable the adaptation of the processing industry to the digital age, and therefore on the basic incentives and sources of their financing.

The aim of the work was to examine the effects of investment in research and development activities of the manufacturing industry on the innovativeness in economy of the Republic of Serbia and to draw conclusions where to direct further investments, bearing in mind that the importance of the processing industry for the overall economy is growing from year to year. Based on the conducted research and analysis of indicators on the example of the Republic of Serbia, the authors emphasize the need to restructure investments in the direction of research and development activities of the manufacturing industry, since a strong connection with indicators of innovativeness in economy of the Republic of Serbia (SII, GII and GCI) in the period from 2014 has not been proven until 2021. This results from the fact that the progress of the economy of the Republic of Serbia observed through the ranking and points of the used indicators of innovation can be attributed to investments in research and development activities in the area of other sectors of the economy, which indicates the need to restructure research and development expenditures in the direction of the manufacturing industry, with the aim of its greater contribution to the overall innovativeness in economy of the Republic of Serbia.

References

Beraha, I. (2019). Ocena inovativnih performansi Republike Srbije, *Ekonomski vidici* 24(3-4).

Czarnitzki, D., Ebersberger, B. & Fier, A. (2007). The relationship between R&D collaboration, subsidies and R&D performance: Empirical evidence from Finland and Germany. *Journal of applied econometrics* 22(7): 1347-1366

Devitt, J. (2017). *The Future of Manufacturing in the Digital Age,* University of Huddersfield: Centre for Industrial Analytics, pp.2-7.

Dutta S, Lanvin B & Wunsch-Vincent S. (Editors) (2018). *The Global Innovation Index 2018: Energizing the World with Innovation,* Cornell University, INSEAD, and the World Intellectual Property Organization, (Downloaded from: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2018.pdf), accessed 06.03.2023.

Gligorijević Ž., Bošković G. (2021). *Industrijski menadžment*, Niš: The Faculty of Economics

González, X., Jaumandreu, J. & Pazó, C. (2005). Barriers to innovation and subsidy effectiveness. *RAND Journal of economics* 36(4): 930-950

Janoskova, K., & Kral, P. (2019). An In-Depth Analysis of the Summary Innovation Index in the V4 Countries. *Journal of Competitiveness,* 11(2), 68–83. https://doi.org/10.7441/joc.2019.02.05

Kim, S. J., Kim, E. M., Suh, Y. & Zheng, Z. (2016). The effect of service innovation on R&D activities and government support systems: the moderating role of government support systems in Korea. *Journal of Open Innovation: Technology, Market, and Complexity* 2(5)

National Science Board. (2012). *Research & Development, Innovation, and the Science and Engineering Workforce: A Companion to Science and Engineering Indicators 2012*, Arlington, VA: National Science Foundation

OECD. (2005). *The Oslo Manual: Proposed Guidelines for Collecting and Interpreting Technological Innovation Data.* Paris: EC, Eurostat.

Prokop, V., Stejskal, J. & Hajek, P. (2019). Effectiveness of R&D Expenditures Supporting Innovation: A Case Study of OECD Countries. In *Proceedings of the 1st International Conference on IT, Communication and Technology for Better Life* (1), 5-13

Statistički godišnjak Republike Srbije, https://publikacije.stat.gov.rs/G2020/Pdf/G20202053.pdf, accessed 05.04.2023.

Savić, Lj. & Mićić, V. (2021), Uloga industrije u ekonomskom razvoju Srbije, *Politička revija,* 68(21).

Savrula, M., Incekarab, A. (2015). The Effect of R&D Intensity on Innovation Performance: A Country Level Evaluation, *The 4th International Conference on Leadership, Technology, Innovation and Business Management,* Procedia - Social and Behavioral Sciences (210), 388 – 396.

Schwab, K. (2017). The Global Competitiveness Report 2017- 2018. *World Economic Forum,* 37-38.

Ulku, H. (2004). *R&D, Innovation, and Economic Growth: An Empirical Analysis,* Authorized for distribution by Arvind Subramanian, IMF Working Paper, Research Department, pp. 4-34

UNCTADstat -United Nations Confernce on Trade and Developmen, Swierland, available at: http://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=95 , accessed 10.03.2023.

European Commission, https://ec.europa.eu/info/index_en , accessed 06.02.2023.

Global Innovation Index 2022, https://www.globalinnovationindex.org, accessed 17.01.2023.

World Compettitiveness Report 2019, https://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2019.pdf , accessed 10.01.2023.

ULAGANJA U ISTRAŽIVAČKE AKTIVNOSTI PRERAĐIVAČKE INDUSTRIJE I INOVATIVNOST PRIVREDE REPUBLIKE SRBIJE

Apstrakt: Cilj istraživanja u ovom radu je da se ispitaju efekti ulaganja u istraživačko-razvojne aktivnosti prerađivačke industrije na inovativnost privrede Republike Srbije i donesu zaključci u kom pravcu je potrebno usmeravati dalja ulaganja, imajući u vidu da značaj prerađivačke industrije za ukupnu privredu, iz godine u godinu, raste. Komparativnom analizom prikazuje se kretanje osnovnih pokazatelja sektora prerađivačke industrije, kao i kretanje tri osnovna pokazatelja inovativnosti privrede Republike Srbije: GII (Globalni indeks inovativnosti), GCI (Globalni indeks konkurentnosti) i SII (Sumarni indeks inovativnosti). Na osnovu primene regresione i korelacione analize uviđa se slab doprinos bruto domaćih izdataka za istraživanje i razvoj u prerađivačkoj industriji poboljšanju inovativnosti privrede Republike Srbije. Sa druge strane, utvrđena je snažna veza između ukupnih bruto domaćih izdataka za istraživanje i razvoj (na nivou privrede) i pokazatelja inovativnosti privrede, što ukazuje na potrebu prestrukturiranja izdataka za istraživanje i razvoj u pravcu prerađivačke industrije, sa ciljem njenog većeg doprinosa inovativnosti ukupne privrede. Napredak privrede Republike Srbije sagledan kroz rang i poene korišćenih pokazatelja inovativnosti može se pripisati ulaganjima u istraživačko-razvojne aktivnosti u oblasti drugih sektora privrede, što može biti tema nekog budućeg istraživačkog rada.

Ključne reči: istraživačko-razvojne aktivnosti, bruto domaći izdaci za istraživanje i razvoj, inovativnost privrede, prerađivačka industrija, GII, GCI, SII

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